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Notes on Journal Articles on Nature of Glass

Being Substantially a Talk Given Before Princeton Section American Chemical Society, *April 24, 1931*

By Dr. E. C. Sullivan, Vice-Chairman, Corning Glass Works

THE review below by Dr. Sullivan is a very timely analysis of the bearing of recent researches on the causes of the peculiar properties of glass, a material which has refused hitherto to be explained in terms of any other materials. Glass is a material more or less apart, and the reasons for this may possibly be now gradually coming to light.—*F.W.P.*

DEVELOPMENTS along several distinct lines have led to a revision of the view that glass is simply an undercooled liquid.

The suggestion has been put forth that glass should be classified between liquid and solid, and even that it should rank as a fourth state of matter[2] with the three states—gas, liquid and solid—hitherto recognized.

Among the facts added in recent years to our knowledge of glass are the following:

1. A discontinuity in physical properties in the transition glass-liquid.
2. Heat reaction in the transition glass-liquid.
3. Equation of state for glass differing from that for liquid.
4. X-ray evidence that some glasses consist largely of minute crystals.

The changes that take place when glass is softened by heat are actually parallel to those in a melting crystal, and this is true whether we are dealing with high-melting glasses such as silica or silicates, or with lower-melting glasses like boric oxide, selenium or glycerin. The properties of glass do not, as had been assumed, go over gradually to those of the molten state. There is, on the contrary, a discontinuity in the curves of all properties thus far examined.

The viscosity of commercial soda-lime glass, for instance, decreases slowly at first, as the glass gets hot, then through a certain critical temperature interval it falls one-half for a few degrees rise in temperature. At still higher temperatures 100° are required for a drop of one-half. Upon cooling, the glass does not simply become more and more viscous but instead it suddenly becomes rigid.

There are similar jogs in the curve for specific heat,[3] expansion-coefficient, specific gravity, refractive index, electric resistivity, dielectric constant and other properties. For a given glass these discontinuities all occur in the same temperature range, namely, that in which the glass begins to soften.

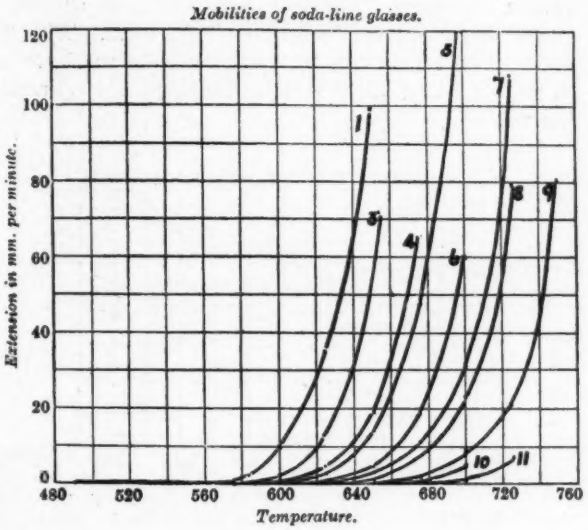


FIG. 1. MOBILITY EQUALS ONE-THIRD VISCOSITY. ENGLISH, J. SOC. GL. TECH. 7, 33 (1923).

At this temperature of transformation from glass to liquid the viscosity is identical for all glasses investigated, irrespective of chemical composition and irrespective of position in the temperature scale, which varies for different glasses from—88° C. to +700° C. or higher. That viscosity is always approximately 10^{13} poises.[4] With low-melting glasses such as selenium and organic glasses Tammann determines the transformation point with an accuracy of 1° or 2° by drawing a steel needle over the surface. In glass the result is a jagged scratch; in viscous liquid it is a

[1] Berger, Gl. Ber. 5, 393 (1927); Tammann, Zeits anorg. Chem. 182, 49 (1929); Tammann, Gl. Ber. 7, 445 (1930); Maurach, Gl. Ber. 7, 425 (1930).

[2] Parks & Huffmann, J. Phys. Chem. 31, 1842 (1927).

[3] W. P. White, Am. Jour. Sci. [4] 47, 44 (1919).

[4] Samsoën. C. r. 182, 517 (1926).

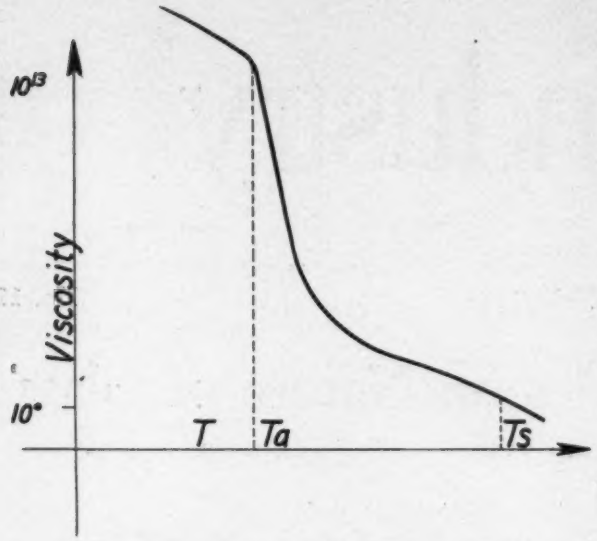


FIG. 2. RELATION BETWEEN VISCOSITY AND TEMPERATURE OF GLASSES. Ta = TRANSFORMATION POINT; Ts = SOFTENING POINT. TAMMANN, ZEITS ANORG. CHEM. 156, 245 (1926).

smooth depression. Tammann defines glass as an undercooled liquid that can be scratched or cracked. With the ordinary silicate glass no sharp line can be drawn, the transformation taking place over a considerable temperature interval.

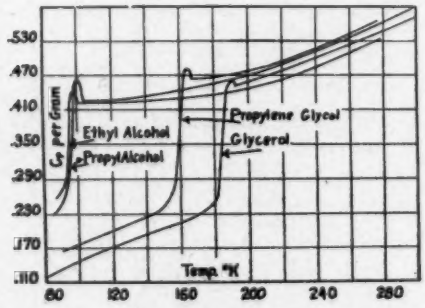


FIG 3. DISCONTINUITY IN SPECIFIC HEAT OF ORGANIC GLASSES. PARKS & HUFFMAN, J. PHYS. CHEM. 31, 1842 (1927).

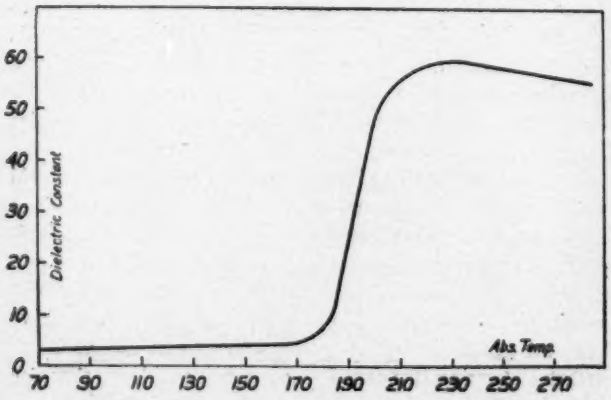


FIG. 4. DISCONTINUITY IN DIELECTRIC CONSTANT OF GLYCERIN GLASS. FLEMING & DEWAR, PROC. ROY. SOC. LONDON, 63, 124 (1897).

A marked absorption of heat occurs when glass is heated through the transformation temperature.[5] For glycerin and n-propyl alcohol, which are known both in the glass and

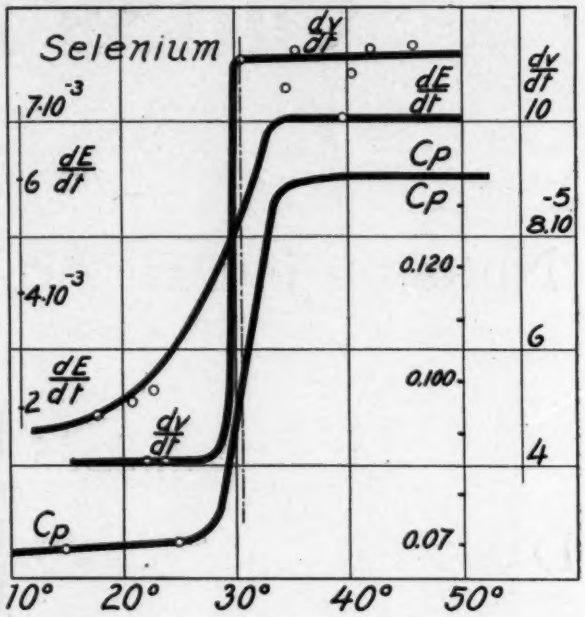


FIG. 5. DISCONTINUITIES AT TRANSFORMATION TEMPERATURE OF SELENIUM GLASS. v = SPECIFIC VOLUME; E = DIELECTRIC CONSTANT; Cp = SPECIFIC HEAT; —— TRANSFORMATION TEMPERATURE. TAMMANN, GL. BER. 7, 445 (1930).

in the crystalline form, the heat absorbed in the transition from glass to liquid is 30 to 40 percent as great as the heat of fusion of the crystal.[6]

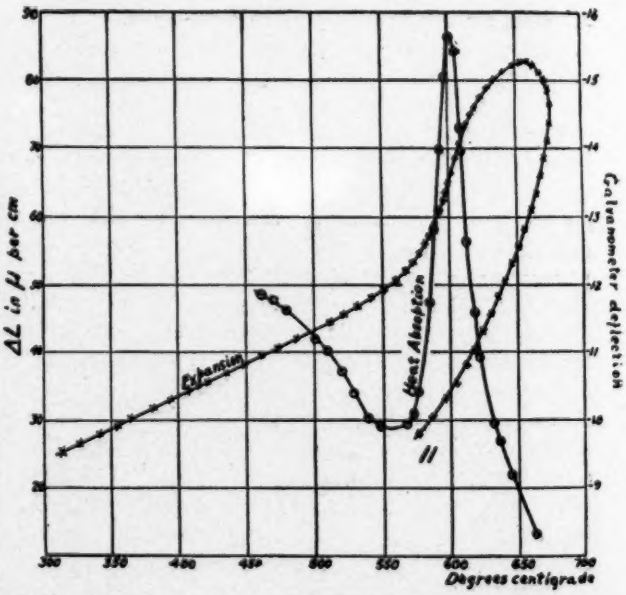


FIG. 6. HEAT ABSORPTION AND DISCONTINUITY IN THERMAL EXPANSION OF BARIUM CROWN GLASS. TOOL & VALASEK, SCI. PAP. BUR. STAND. 358 (1919); PETERS & CRAGOE, IBID 393 (1930).

[5] Quäsebart, Snr. 49, 18 (1916).
[6] Parks & Huffmann, J. Phys. Chem. 31, 1842 (1927).

A fundamental distinction between glass and liquid recently brought to light[7] lies in the fact that while the volume of a liquid is fixed by its temperature and pressure, the volume of a glass depends also on the pressure under

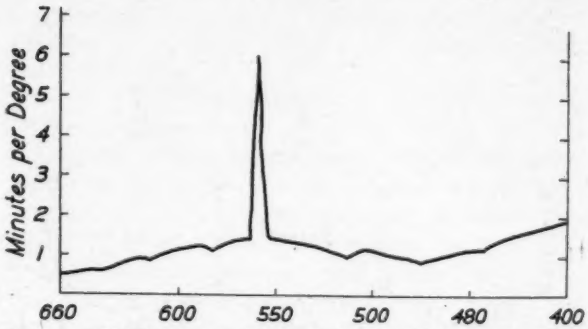


FIG. 7. EVOLUTION OF HEAT AS PLATE GLASS IS COOLED. QUASEBART, SPR. 49, 18 (1916).

which it has become rigid. Boric oxide which has gone over from liquid to glass under a pressure of 5700 kilograms per sq. cm. has a density some five percent above normal. The equation of state for glass, therefore, differs from that for liquid.

The specific heat of glycerin, which is known both as glass and as crystal, is little if any higher in the glass than in the crystal state, and the conclusion has been drawn that the energy content of the glass is no greater than that of the crystal, or in other words that the glass is equal to the crystal in stability. Tammann, however, points out[8] that even though the specific heat of glass and crystal are alike, the energy content of glass in general is greater than that of the same substance in crystalline form.

That certain glasses consist of masses of very minute crystals is the conclusion of investigators in the British General Electric Laboratory.[9] The X-ray diffraction pattern of cristobalite, a high-temperature crystalline form of silica, appears in a borosilicate glass containing 70 percent silica, in glasses obtained by melting feldspar, in silica glass and even in amorphous silica. The figures show the close resemblance between the curves for silica glass and precipitated silica and the curve calculated from the cristobalite curve on the assumption that the crystals are of the dimension of 1.5 x 10^{-7} centimeters. The supposition that borosilicate glasses and silica glass consist largely of the same substance is in harmony with the fact that both have a low thermal expansion-coefficient. A glass of the composition of calcium metasilicate ($CaSiO_3$) the X-ray indicates to consist in all probability of crystallites of pseudo-wollastonite of the order of size mentioned. Borax glass consists of crystallites of anhydrous borax. Soda-lime glass, however, containing 70 percent silica, gave no evidence of cristobalite. It should be mentioned also that certain liquids, benzol, for instance, show the same X-ray pattern as the solid substance.[10]

The same authors point out that crystallite structure would

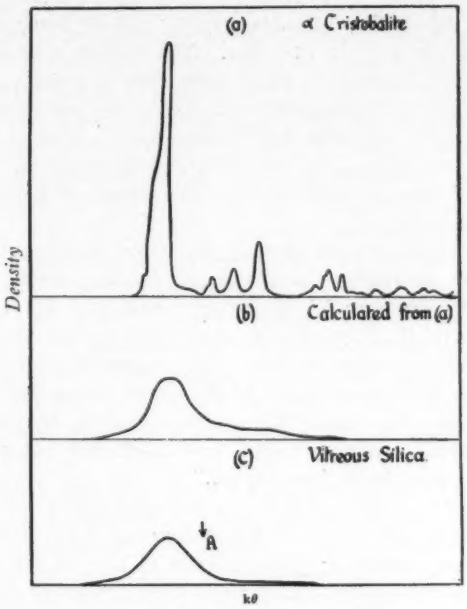
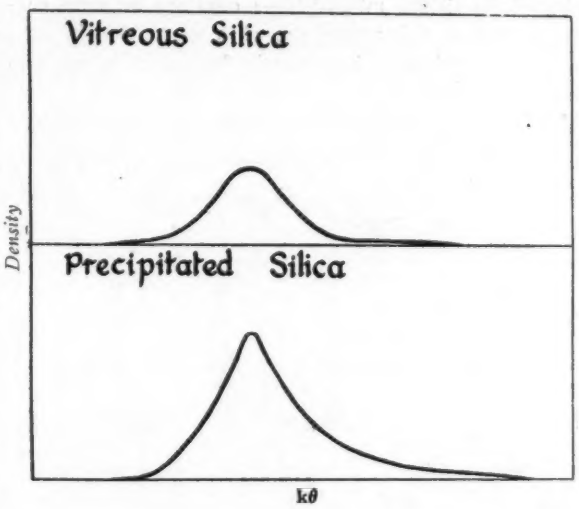


FIG. 8—FIG. 9. X-RAY DIFFRACTION CURVES. RANDALL, ROOKSBY & COOPER, J. SOC. GL. TECH. 14, 219 (1930).



account for the fact that a glass absorbs less heat on softening than does a crystal of the same composition. It is well recognized that very small particles are less stable, that is, have higher energy content, than larger particles. A small drop of liquid has higher vapor pressure than a large drop, and large drops grow at the expense of the small drops just as small crystals have higher solution pressure than large crystals, which grow at the expense of the small ones. A small crystal, to reach a given higher energy level such as that of the liquid at the melting point, would not have so far to go as a large crystal. The latent heat of fusion would therefore be less for an agglomeration of crystallites than for a single crystal.

The gradual softening of glass in contrast with the abrupt melting of the ordinary crystalline substance is also accounted for in that the X-ray results indicate the existence

[7] Tammann & Jellinghaus, Ann. Phys. [5] 2, 264 (1929).
[8] Tammann, Zeits anorg. Chem. 190, 48 (1930).
[9] Randall, Rooksby & Cooper, J. Soc. Gl. Tech. 14, 219 (1930).
[10] Gottfried, Gl. Ber. 8, 401 (1930).

index. The physical properties of a glass even when free from a mechanical strain, therefore, depend upon its thermal history or heat treatment, somewhat as do the physical properties of crystalline materials like cast iron or steel. The alteration of cast iron or steel, however, is due in some measure at least, to differences in visible structure brought about by the heat treatment.

More recently Salmang and v. Stösser[15] have carried out experiments similar to those of Tool but chilling the glass from higher temperatures. They heated powdered glass on a bit of platinum foil to the desired temperature in a furnace and transferred foil and all quickly to a cast iron plate upon which another heavy cast iron plate was instantly dropped. The glass was thus flattened out to a thin plate and consequently was very rapidly chilled. The curve indicates that chilling from temperatures below the transformation point does not affect the density. The far higher temperatures and more rapid chilling of these experiments produced little more lowering of density than Tool observed, a result which points to the conclusion that equilibrium sets in fairly promptly at the higher temperatures where the glass is less viscous. Salmang and v. Stösser further worked out the relation between the density which follows chilling from a certain temperature and the actual density at such temperature. Tool had concluded that the chilled glass was in a condition corresponding to approximate equilibrium for the temperature from which it was chilled, provided always that the treatment at that temperature before chilling was long enough to produce an equilibrium condition, and provided further that the chilling was severe enough to prevent a drift along the curve representing the temperature-energy level of equilibrium relations. Salmang and v. Stösser evaluate for a limited range of temperature the magnitude of that approximation. They do this by determining the expansion-coefficient at various temperatures up to the softening range, thus providing actual measurements of density at the temperatures from which the glass was chilled, for comparison with the abnormal densities which resulted from the chilling. The curve indicates that the density after chilling is about halfway between the normal and that of the temperature from which chilling has taken place.

Tool, by demonstrating that the density upon chilling was a function of the duration of heating, had proved that he was dealing with something other than thermo-elastic strain. Salmang and his associate corroborate this by an independent and very simple method. You are familiar with the Prince Rupert drops of high school physics, made by letting drops of molten glass fall into water, thus throwing them into such a state of strain that breaking off the tail of the drop causes it to fly into powder. The specific gravity of such a drop was determined to be 2.4439. Grinding it to fine powder, which presumably would relieve mechanical or thermo-elastic strain (and incidently double-refraction), raises the specific gravity by seven units in the fourth decimal place, to 2.4446. Thorough annealing, however, which relieves molecular as well as thermo-elastic strain, raises it further, to 2.4620, nearly 200 in the fourth place above the specific gravity of the glass as originally strained. The conclusion seems justified that considerable strain exists which is not relieved by mechanical means.

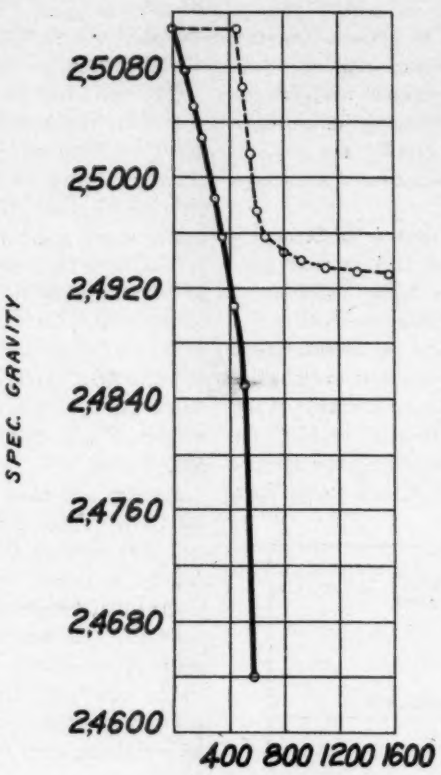


FIG. 16. CONTINUOUS LINE SHOWS ACTUAL SPECIFIC GRAVITY AT QUENCHING TEMPERATURES. BROKEN LINE SHOWS SPECIFIC GRAVITY AFTER QUENCHING. SALMANG & v. STOSSER. GL. BER. 8, 463 (1930).

The sum of it all is that transformation from glass to ordinary liquid is accompanied by heat reaction and discontinuities in physical property curves such as we associate ordinarily with changes in physical state. Unlike the ordinary liquid the volume of glass is not defined by temperature and pressure alone. The X-ray indicates that some glasses, at least, consist of minute crystals and it is possible to some extent to correlate physical properties with such crystalline structure.

The retardation observed in attainment of equilibrium means that something more goes on in the glass than an instantaneous adjustment of properties to temperature changes. There is a reaction that requires time. Much discussion has evoked no real evidence whether this reaction on cooling is, for example, a formation of molecular aggregates,* a decrease in space between molecules, or a shrinkage of the molecules themselves. All these views as well as others have had very respectable proponents.

It seems natural to attribute such retardation to the high viscosity of the material. The viscosity range in which all these phenomena take place is identical for all glasses of whatever composition. Viscosity is in a sense the controlling factor. Possibly here is a basis for a more satisfactory definition of glass than we have had hitherto.

[15] Gl. Ber. 8, 463 (1930).

* At higher temperatures than those here under discussion (900° to 1000° C. for soda-lime glass) Fulcher finds a change in direction in the viscosity-composition curve which he attributes to molecular aggregation.[16]

[16] J. Am. Cer. Soc. 8, 339 and 789 (1925).

"SYMPOSIUM ON ULTRAVIOLET SOURCES," by Greider & Downes, W. W. Coblentz; L. J. Buttolph, J. W. Marden & M. G. Nicholson—Tr. Illum. Eng. Soc., July, '31.

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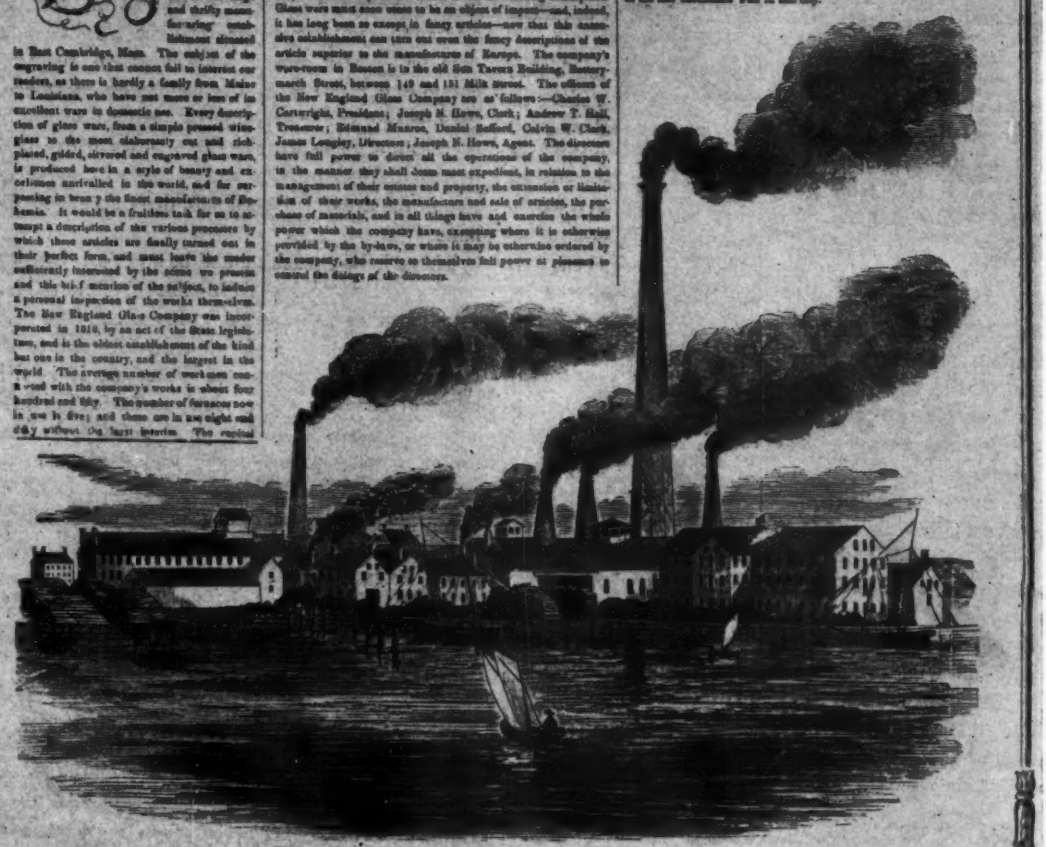
VOLUME I. BOSTON, SATURDAY, NOVEMBER 8, 1851. NUMBER 28.

NEW ENGLAND GLASS WORKS.

YOUR true artist understands well how to produce effect in a picture, and is convinced by sound judgment in the selection of his subject. Our artist has given us here a fine and successful picture of this large and thrifty manufacturing establishment situated in East Cambridge, Mass. The subject of the engraving is one that cannot fail to interest our readers, as there is hardly a family from Maine to Louisiana, who have not more or less of its excellent ware in domestic use. Every description of glass ware, from a simple pressed wineglass to the most elaborately cut and richly-plated, gilded, silvered and engraved glass ware, is produced here in a style of beauty and excellence unrivalled in the world, and far surpassing in brilliancy the finest manufactures of Bohemia. It would be a fruitless task for us to attempt a description of the various processes by which these articles are finally turned out in their perfect form, and must leave the reader sufficiently interested by the scene we present, and this brief mention of the subject, to induce a personal inspection of the works themselves. The New England Glass Company was incorporated in 1818, by an act of the State legislature, and is the oldest establishment of the kind but one in the country, and the largest in the world. The average number of workmen connected with the company's works is about four hundred and fifty. The number of furnaces now in use is five; and these are in use eight months in a year, without any intermission. The capital stock of the company is $400,000, on which a semi-annual dividend is paid, the earnings of the company affording a large per cent. of profit, and its shares are never to be found in the market. The height of the immense chimney which forms so prominent a part of the picture, and which looms up so loftily to the eye that regards this part of Cambridge from a distance, is two hundred and thirty feet; actually ten feet higher than Bunker Hill Monument. Into this lofty flue all others connected with the main works centre, even the blacksmith's shop; and, indeed every fire, either of the large furnaces or the smallest chip is connected with the chimney by tubes running under ground. Thus all the smoke and gases from the main works are let off at so great a height as to prevent all unpleasant effects to the surrounding atmosphere. Glass ware must soon cease to be an object of import—and, indeed, it has long been so except in fancy articles—now that this extensive establishment can turn out even the fancy descriptions of the article superior to the manufactures of Europe. The company's ware-room in Boston is in the old Sun Tavern Building, Battery-march Street, between 149 and 151 Milk street. The officers of the New England Glass Company are as follows:—Charles W. Cartwright, President; Joseph M. Howe, Clerk; Andrew T. Hall, Treasurer; Edmund Munroe, Daniel Safford, Calvin W. Clark, James Longley, Directors; Joseph B. Howe, Agent. The directors have full power to direct all the operations of the company, in the manner they shall deem most expedient, in relation to the management of their estates and property, the extension or limitation of their works, the manufacture and sale of articles, the purchase of materials, and in all things have and exercise the whole power which the company have, excepting where it is otherwise provided by the by-laws, or where it may be otherwise ordered by the company, who reserve to themselves full power at pleasure to control the doings of the directors.

Persons visiting this section of the country from a distance rarely fail to make this establishment a subject of careful study and visitation; but singularly enough, persons residing within a moderate of its walls have comparatively little or no interest in the works upraised by which the beautiful ware produced here is brought to the state of perfection it evinces when ready for use. The process of plating, gilding, silvering and engraving are of very modern discovery, and are most curious in detail and general operation. *A propos* of this part of the manufacturing process, we may add that the company has some of the most skillful artists in its employ to be found in the world. This fact is attested by the elegance of the articles produced here, many of which were exhibited at the last Mechanics' Fair in this city.



NEW ENGLAND GLASS COMPANY'S WORKS, EAST CAMBRIDGE, MASS

The Manufacture of Rolled Plate

By ERNST LUTZ *

(*Continued from the October, 1931, issue*)

This work has been revised, so far as the English and the technical expressions are concerned, by F. W. Preston, who has also added a number of notes relating in general to the special conditions of American practice; but it must be understood that the opinions expressed in the text are those of Mr. Lutz, and neither the Editor nor Dr. Preston accepts responsibility for them.

THE grinding discs start to turn and with ratios of table and disc diameters, as for instance illustrated in the figures, they gradually reach almost the same number of revolutions as the table itself. A watch must be kept that the discs assume the same direction of rotation as the table. Towards the edge of the table the glass surface evidently moves in the same direction as the corresponding runner bars, but a point of the glass surface moves more quickly than a point on the disc; towards the middle of the table, glass surface and grinding disc move against each other, ensuring a sufficient and uniform grinding over the whole of the glass surface.

If the surface of the glass has been ground so much that the discs rest not on points but on larger spots, depending on the design of the apparatus, the discs are allowed to press with almost their full or even with their entire weight on the glass; in this way the grinding is carried on until all rough spots of the original rough glass skin are eliminated. For the fine grinding or smoothing the same pressure of the grinding discs on the table is maintained. When the smoothing is finished, the drive of the king-shaft is switched off and the movement of the table is gradually stopped; by the braking action of the grinding discs; if a quicker retardation of the table is required, the driving motor itself is braked or alternatively a separate mechanical brake is used. The runners are then raised, the rail ends c also lifted (or, alternatively, the king-shaft lowered) until the table stands again with its wheels on the rails and can be removed for another one to take its place.

In order to protect the surroundings of the grinding apparatus from sand and waste thrown off and also from glass fragments, the machine is enclosed in a protecting wall v. (Fig. 125.) The opening through which the table is inserted and withdrawn can be closed with a movable door t. The mixture of crushed sand and water thrown from the grinding table is collected in the gutter w which runs all round the whole machine, and is flushed with a jet of water into the grading apparatus; the mixture also contains fragments of plaster, pulverized glass and iron originating from the wear of the runner bars. On the platform of the grinding machine the boxes are arranged from which in succession the rough sand and the graded material is led to the gutter u and thence distributed over the grinding table. The material coming from the sand store and the residues from the grinding table is either first washed and graded in a preparing plant or the boxes x are so designed that they are able to do the grading themselves. The surplus and waste matter is returned to the clearing basin through y; the gutter w has to be made deep enough so that none of the mixture can overflow into the basement where the king-shaft and its drive are situated.

The gradual lowering of the grinding discs l and m on to the grinding table at the beginning of the grinding with the beam s and the shafts o is either done hydraulically or with the aid of counterweights s_1 with which the rear arm of the beam s can be released more and more. If required, the last fine setting can be done with the aid of a spindle and a hand wheel z. This hand wheel can escape freely in the downward direction so that the beam s, either with a hydraulic arrangement or with the weights s_1, can at any time be quickly moved downwards. A further means for controlling pressure of the runner on the glass surface is provided by the water tank s_2 arranged at the back end of the beam s, in which more or less water can be kept. This particular regulation is mainly used to equalize the variation of the grinding disc weight due to the wear of the runner bars.

The grinding machine and its auxiliaries are both operated from a platform, which is so situated above the table that the grinding discs and also the gutter w can be easily inspected. The platform has to be washed frequently, the washing water running down to the gutter w; it is therefore best made of concrete. The platform is further provided with fairly high edges so that during fine grinding no sharp grains or other foreign matter can drop on to the grinding tables.

During its rotation the grinding table will always rock slightly and the runners must be able to follow this movement. As mentioned before, the runners have some clearance in the spiders n; this, however, is not sufficient to accommodate the rocking of the table, and the shaft o must be able to give way a little in every direction. For controlling the position of the runner relative to the table surface, the upper bearing q is arranged as a universal joint and its outer casing is somewhat movable; one of the two joint-pins is extended and provided with a thread on which a worm wheel q_1 sits as a nut and is rigidly fixed relative to the frame r. This wheel q_1 is driven by a worm and a hand wheel q from the platform. With the aid of this device the grinding disc in question can be more or less inclined towards the middle or the edge of the grinding table. In another design as shown in Fig. 139, the lower bearing H can be set with wedges M by the hand wheels O.

* Of Dessau, Germany. This work is appearing in German in the new edition of *Dralle-Keppeler*, "Die Glasfabrikation."

FOOTNOTE: In the Figures, originally prepared for use eventually in the new edition in the German language of *Dralle-Keppeler*, "Die Glasfabrikation" in 1931, dimensions are given in metres (*m*) and millimetres (*mm*). We would like to have given these in feet and inches but the translation and the making of nearly two hundred and fifty new illustrations would have involved a prohibitive loss of time and expense. To some of our readers the metric system is as familiar as the English units; for the others we may say that a metre is approximately 40 inches, and a millimetre is approximately 1/25 of an inch. A thousand millimetres, of course, go to a metre.—*F. W. P.*

The main body of the grinding disc is of cast iron; on its lower face it carries a layer of strong hard wood, usually oak to which the iron grinding bars are screwed. Figs. 140-142 show various designs of runner bars. The one illustrated in Fig. 142 is said to be most efficient for grinding; however, in some factories it was found that bars as shown in Figs. 140 and 141 give a better smooth as they present a greater compact grinding surface and can also be washed more easily than those of Fig. 142, where sharp sand grains may remain. The holes in the bars as shown in Fig. 140

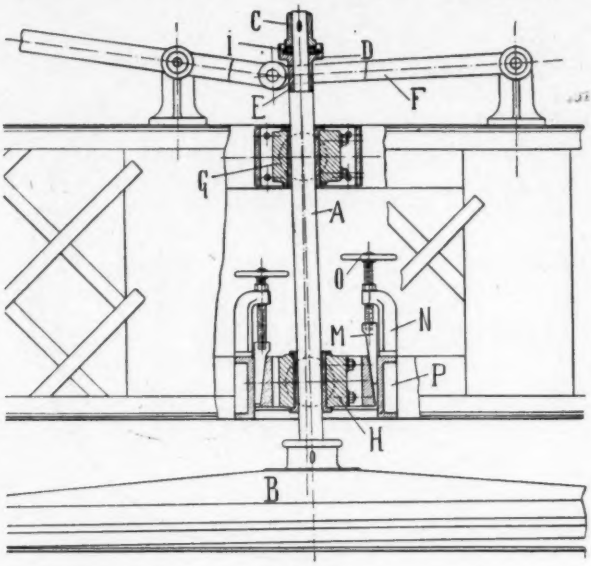


FIG. 139
DESIGN OF THE LOWER BEARING H (From first edition of Dralle)

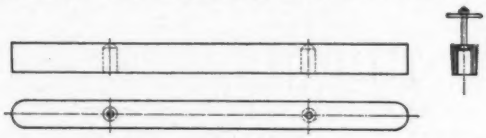


FIG. 140

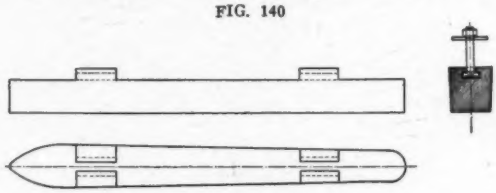


FIG. 141

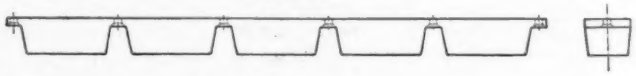


FIG. 142

through which the bolts are pushed, have to be plugged with wood in order that they may not collect sharp grains, which at an undesirable time may fall on the glass surface. These wooden plugs sometimes fall out, and to avoid them altogether, the bars, according to Fig. 141, are fitted with lugs, into which the bolt heads can be dovetailed; in this case the wooden decking of the grinding discs must have recesses into which the said lugs fit. The casting of bars with such lugs is more difficult than that of other forms; if the greatest care is not taken in the foundry, cavities and blow-holes will form near the lugs, which only become apparent after part of the iron has been ground off. These cavities will then collect sharp grains which during the smoothing will spoil the glass surface.

A favorable distribution of the grinding sand on the table is important, but the manner of arranging the bars on the runner has also a great influence on the grinding efficiency; it is essential that the sand carried with the table should be efficiently brought in between the bars, and that it cannot escape without being used, but is properly caught by the bars. All parts of the glass surface should be worked as uniformly as possible. Very often all irons as shown in Fig. 143 are arranged radially on the grinding disc. Fig. 144 shows in between the curve A_1 and B_1 the surface which the radially situated grinding iron a_1 b_1 covers on the assumption that the grinding disc revolving round the axis M has the same number of revolutions per minute as the table itself; the end a_1 of the iron follows the curve A_1, the other end b_1 the curve B_1. It is evident that in the position 1 shown, the iron relative to the table moves vertically to its own longitudinal axis and then towards the change-over point v_1 gradually assuming a lengthwise movement; at v_1 the direction of movement is changed, at 1′ and relatively to the table it moves again vertically to its own longitudinal axis and over the point w_1 returns to 1. The highest grinding efficiency is reached in the relative positions 1 and 1′, the lowest at the points v_1 and w_1. The adjacent grinding iron 2 governs a similar surface on the table with the change-over point v_2 and w_2, the next following iron 3 a surface with the change over points v_3 and w_3 a.s.o. These change-over points all lie on a circle W-W round the centre of the table. Along this circle a zone arises on the glass which is less intensively worked than the remaining glass surface. Now, generally speaking, the number of revolutions of the grinding disc will be more or less below that of the table, i. e. a runner

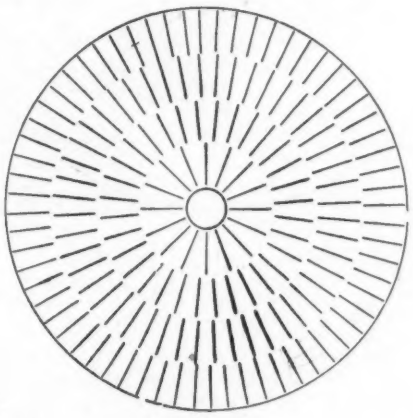


FIG. 143

bar will not continually run over the area as shown in Fig. 143, but will rather cover an area as shown in Fig. 145. However, here again the change-over points of all radially situated irons will be on one and the same circle which represents a less worked zone.

In order to balance this effect only part of the runner bars are placed radially while the rest are set crosswise as

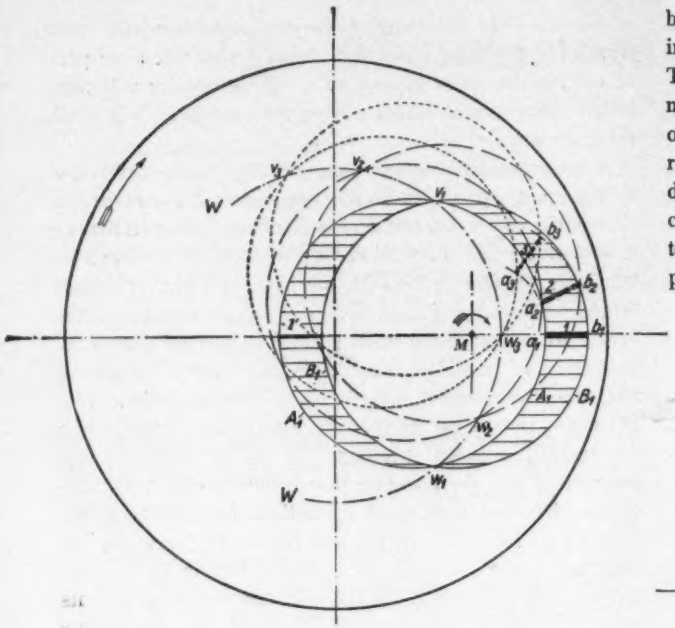


FIG. 144

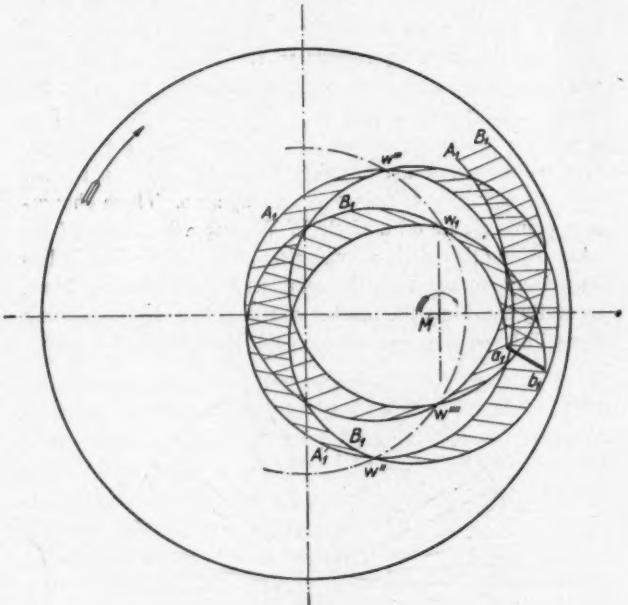


FIG. 145

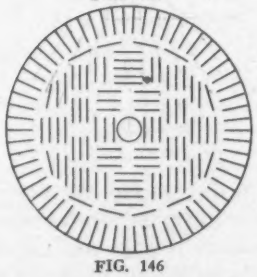


FIG. 146

shown in Fig. 146. A comparison of Fig. 147 with Figs. 144 and 145 shows that the change-over points of the cross bars fall into the zone most intensively worked by the radial bars, while the change-over points of the radial bars fall into the most intensively worked range of the cross bars. This arrangement, however, has the drawback that the admission of the grinding sand and its uniform distribution over the whole grinding disc is more difficult than with a radial setting. In particular the washing of the grinding discs and of the inner grinding bars is rendered more difficult, i. e., the danger that rough sand grains may remain to spoil the fine grinding of the succeeding sand and emery processes, is increased. With such an arrangement the

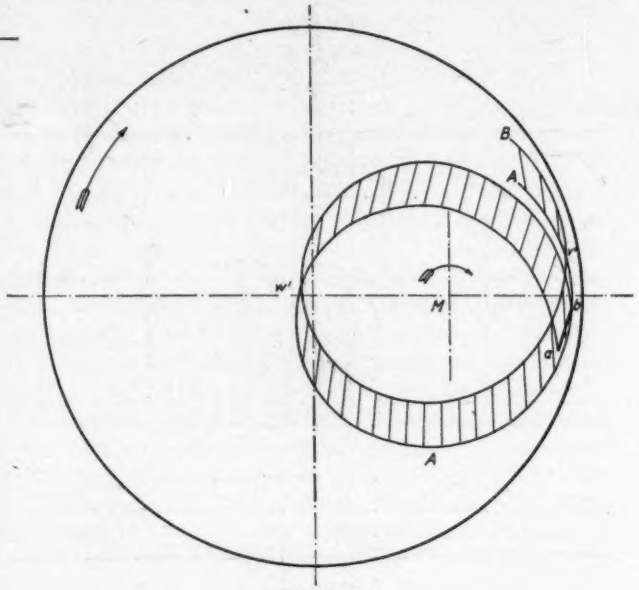


FIG. 147

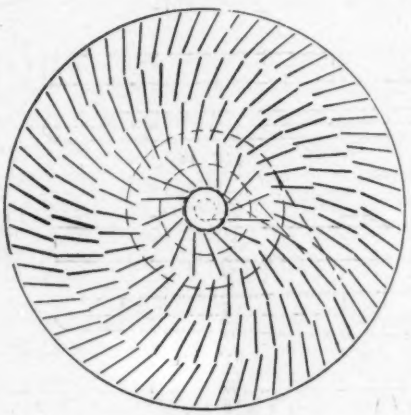


FIG. 148

washing has to be prolonged and must be very carefully done, particularly at the centre of the disc, for instance, by forcing water through the hollow shaft. In spite of the said drawbacks this arrangement is usually given preference over the strictly radial setting. The middle course is represented by an arrangement as shown in Fig. 148 where the zones least worked by the various grinding bar groups are set to compensate each other.

In those machines where for the setting of the grinding table on to the cone, the king-shaft itself is raised and not the rails, a spur gear has to be provided in place of the bevel wheel g (Fig. 136), so that the gear engagement during

this movement is maintained. Figs. 149 and 150 show an apparatus with such a drive as adopted and used during the years 1910-1914 in some new factories. Each machine is driven by a separate motor, with a belt drive to the pulley. For the apparatus illustrated in Fig. 153 a slow speed direct current motor of 500 volts capacity, with vertical axis, is adopted. Its pinion engages, without any additional gear, motor by a flexible coupling which makes it independent of the latter's movements. By this arrangement heavy shocks to which the machine is exposed are not transmitted with their full force to the motor; for drives as shown in Figs. 136 and 149 rope or belt drives represent the elastic interconnection.

The king-shaft makes 27 revolutions per minute, the

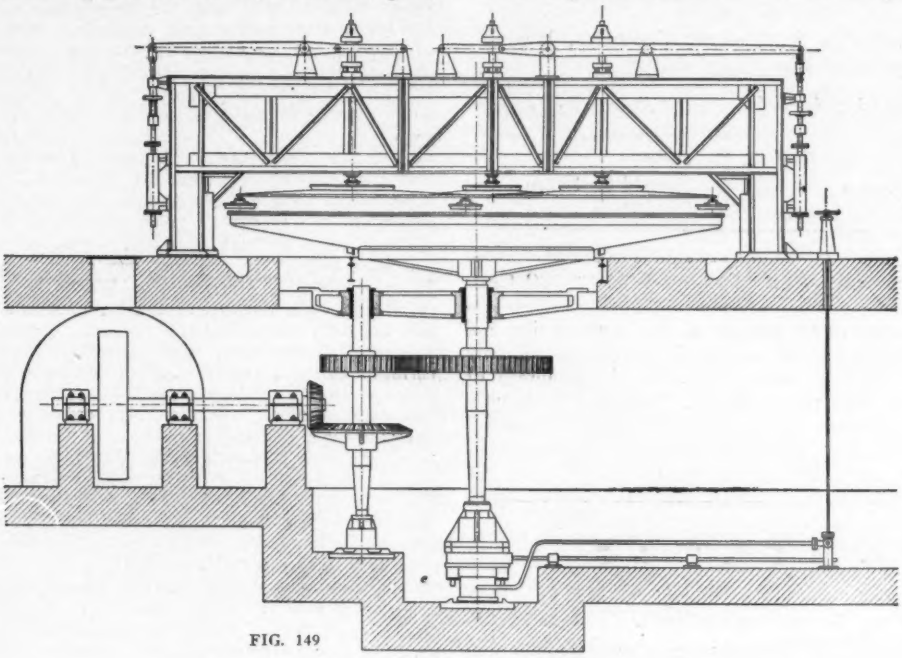


FIG. 149

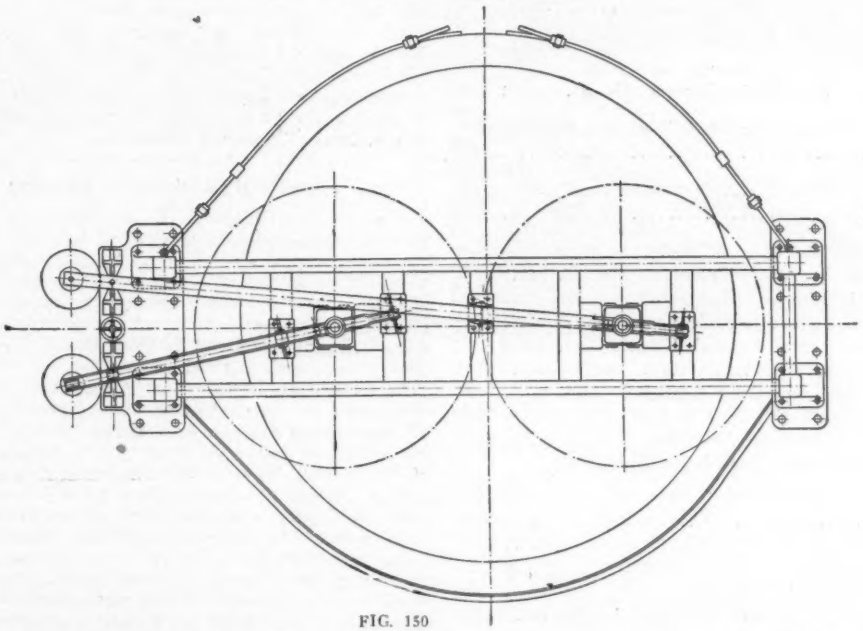


FIG. 150

immediately with the large wheel fixed to the king-shaft; the teeth of this gear have to be cut very accurately and provision must be made that the engagement takes place over the full width of the teeth. Further, the distance between pinion and wheel axis must be kept constant; for this reason the pinion is not keyed on the motor shaft, but turns freely on a particularly strong shaft and is only connected with the motor 270; with a gear ratio of 1:10 the motor pinion has a diameter of 15 ¾" and 25 teeth, the large wheel a diameter of 157½" and 250 teeth, so that the pitch is .63 π. The width of the teeth is 14"; the pinion is made of phosphor-bronze, the large wheel of cast steel. Modern machines are equipped with 5000 volt A. C. motors of 150 r.p.m. with vertical axis and gearing.

Glass Industry

ESTABLISHED 1920

The First Trade Journal Devoted Primarily to Glass Technology, Engineering, Raw Materials and Glass Factory Equipment and Operation

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Vol. 12 NOVEMBER, 1931 No. 11

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Reference to the contents of earlier issues of THE GLASS INDUSTRY can be found in THE INDUSTRIAL ARTS INDEX in many Public and Technical Libraries.

The National Physical Laboratory

The report on the National Physical Laboratory for the Department of Scientific and Industrial Research, for the year 1930, has been published by His Majesty's Stationery Office for the Department of Scientific and Industrial Research, 1931. Price 12s. 6d. The contents include the activities of the general board and the laboratory committee's report of the executive committee laboratory and other activities of the Society. The report of the optics division states that the investigation of optical systems has led to some very general conclusions regarding the methods of carrying out calculations for combinations of lenses. An interesting paper on modern optical glass has been prepared for publication. A specific proposal for the adoption of a standard set of mixture curves to define the "normal" eye for colorometric purposes was made. Total transmission measurements were made by the new spectrophotometer described in the 1929 annual report on a number of glasses for use in photometric determinations. With these a study of flicker photometry for large color differences will be made. Other work included the illumination of light wells in high buildings. Measurements on diffusing glassware and an investigation into direct lighting were made. In the volumetric glassware for hydrometers, the drafting of specifications and methods of test for glassware used for testing milk and milk products is now in hand. A number of ultraviolet absorption measurements were carried out in the Physics Department during the year. Spectrophotometric tests were made on a considerable number of specimens of glass designed to transmit more ultraviolet radiation than ordinary window glass to determine the percentage transmissions at various wave-lengths both before and after prolonged exposure to radiation of various types. There is an appreciable demand for the determination of transmissive properties of glass designed for protective purposes with special reference to the total heat transmitted. Among colorometric tests made during the year were various makes of safety glass compounds which were examined for discoloration on long exposure to ultraviolet radiation. The effect of temperature on the red glasses used in optical pyrometers was investigated. The measurements of the transmission of blue glasses in accordance with the program outlined in 1927 have now been completed by the four national laboratories taking part in the investigation, viz.: The Bureau of Standards, the Physikalish-Technische Reischsanstalt, Laboratorie Central d'Electricité and the National Physical Laboratory. The National Illumination Committee of Great Britain will hold its eighth plenary season in England in 1931 and this will be associated with a more general International Illumination Congress.

Cornell Man Discovers Element No. 87

A report from Ithaca, N. Y., on October 15 disclosed the fact that one of the two missing chemical elements, No. 87 and 85 in the atomic scale had been found by Jacob Papish, Professor of Spectroscopy at Cornell University. It was discovered that this element is solid and highly inflammable and is the most sensitive element to light thus far detected. A small quantity of the newly defined element was found by Prof. Papish in samarskite, a lustrous velvety black material.

An explanation of the reason it has taken so long to discover this element is that it does not display great radio activity. So far the element has not been isolated and because of its high inflammability it has been found only in combination. This proof of its existence, however, has been established by its spectograph through the use of a spectroscope. A five-line picture has been made, thus filling a space hitherto shown blank in the spectrum combination. The report says that the element was obtained in a sulphate combination in the ratio of one to two million. Because of the small percentage of the material available in a given quantity of material, the new element will probably never be produced abundantly. Prof. Louis M. Dennis, head of the department of chemistry at Cornell, characterizes the finding of this element as one of the greatest scientific discoveries of modern times.

The Department of Ceramic Engineering, University of Illinois at Urbana is preparing a short course which will be of interest to those engaged in the manufacture of clay refractories for glasshouse use. These courses are designed especially for the benefit of the managers, superintendents, foremen, engineers, etc.

Bold Pioneering in Construction Field Threatens Outworn Methods

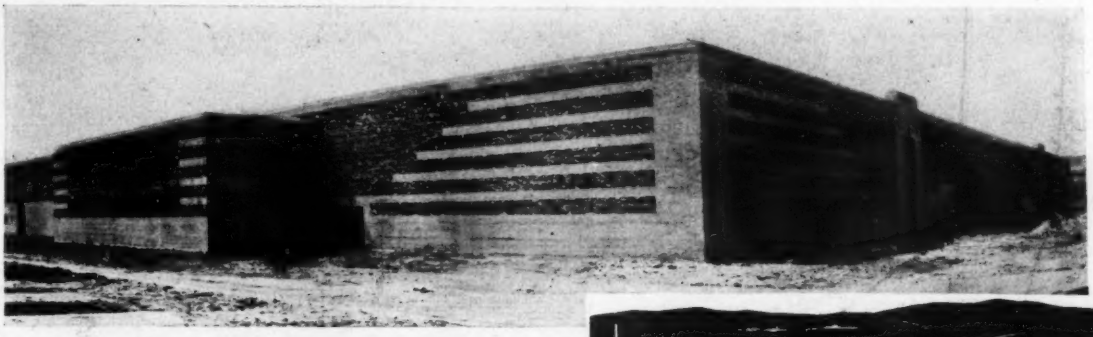
Imaginative Engineers' Ideas Once Deemed Visionary Prove Practical

Prepared for publication from data obtained through the courtesy and collaboration of Mr. A. H. Meyer of The Austin Company by

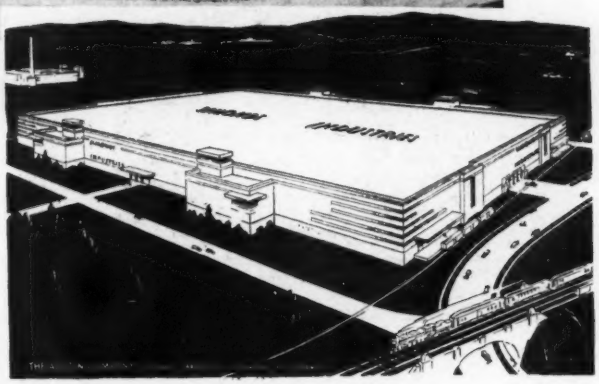
R. D. PROCTOR

READERS of this publication may have noticed frequent references in the trade and daily press to the increasing application of scientific principles to factory design, fabrication and operation, but few seem to realize the extent to which practical results on a commercial scale have been secured in a number of instances through the intelligent application of newly formulated ideas to practical problems.

One such enterprise, fully developed after several years of costly research and experiment and many practical tests, recently came into international prominence because of the novel innovations it embodied. It is a project, referred to in an earlier issue, for the construction of the first windowless factory, a decidedly novel venture which will be watched with genuine interest by all interested in factory buildings, when manufacturing operations begin.



Windowless "Controlled Conditions" Saw Manufacturing Plant of Simonds Industries, Inc., Fitchburg, Massachusetts. 360 x 560 Ft. Frame of Welded Steel. The Austin Company, Architects, Engineers, Builders.



Architects Sketch of Building in Perspective

This pioneer development along a new and previously unexplored line was courageously entered into last year by the Simonds Industries, Inc., of Fitchburg, Mass., of which Alvan T. Simonds is president, with W. J. Austin, president of The Austin Company of Cleveland. The Cleveland concern, experienced architects, engineers and builders, agreed to prepare designs for and construct an entirely new type of factory, entirely windowless, depending completely for its light on artificial sources. This building is now in an advanced state of construction, nearing completion.

The windowless feature is not the only novel venture involved in the project. Operating conditions have been studied intensively. The plant will be essentially a scientifically "Controlled Conditions" plant. Every precaution has been taken to make working conditions for the employes far safer, healthier and more comfortable than in the ordinary plant.

The equipment is designed to employ two shifts daily with possibilities for three shifts later, if needed. Two shifts mean a fifty per cent smaller investment in machinery and increase in the production by each individual machine until it becomes worn out or obsolescent. Research and experiment on an adequate scale to assure success covering the lighting, heating, ventilating and other air-conditioning equipment has developed effective methods for fully controlling all conditions, including even the minimization of noise and its entire elimination where possible.

Many times in discussions concerning the Simonds windowless plant the question has come up as to how seriously the general adoption of the windowless plan might eventually affect the window glass industry. No satisfactory answer to the question has been given. However, it should be remembered that any loss to the window glass industry may be largely offset and be of benefit to the illuminating glass industry because of the very extensive increase in the use of glass bulbs, reflectors and other fixtures.

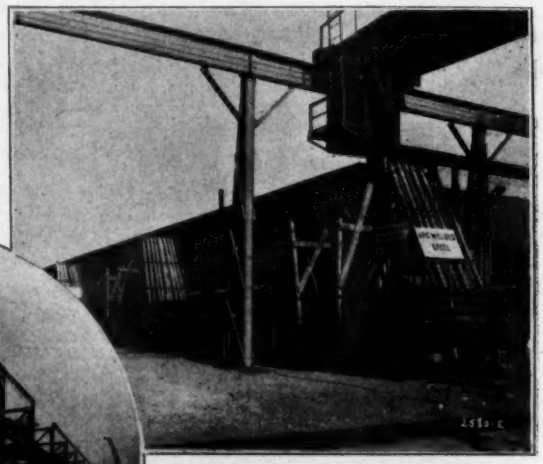
Coincidentally, at the time the Austin plans for the Simonds buildings, one of the most unique undertakings ever attempted in the field of construction were maturing, the Austin organization was also engaged in another decidedly interesting project of great potential importance to the building industry, of which the glass industry is an important subsidiary,—namely the substitution of their noiseless electric welding process for the hitherto indispensable noisy and inefficient riveting method, in the fabrication of steel structures. An idea of the extent to which this new industry of welded steel has progressed since that time may be had from the pictures on these pages and from the fact they by no means fully disclose all that has been accomplished to date by the proponents of welded steel construction. Besides the Simonds work the welding process is being used for the General Electric million dollar filament factory, all of welded EleKtro-Design, at Cleveland and in numerous other places. Added evidence that the electrical welding process has come to stay may be found in the announcement made recently that General Electric has established at Schenectady, N. Y., a School of Welding Design to teach engineers, architects, draftsmen, and others, without charge, approved methods of designing welded buildings.

The welder's torch will almost certainly displace the noisy and otherwise objectionable riveting method, especially in congested cities where hospital and other patients as well as citizens in general have strenuously objected to it for many years and until now without avail.

It was early in 1930[1] after years of costly experimentation and research that Austin first publicly announced their new service in welded steel construction as the beginning of a new era in the building art, at a cost comparable with the prevailing cost at that time of other forms of construction. In March, 1931, a supplementary announcement told of an even more surprising development—Austin was offering noiseless welded construction at *less* cost than the riveted type.

For years past the company has made a specialty of glass factory construction including structural steel buildings by the riveted process and presumably is as well qualified to judge the merits of a construction process as anyone. Its constructional activities have covered this country and extended to foreign lands; —Russia, for instance, where the Austin organization is erecting a $60,000,000 automobile plant which the Soviet Government will devote to making automobiles of the Ford type. The more important buildings are fitted with double window glass because of the intense cold experienced every winter in the region where the plant is located.

General Electric Company Building, Fort Wayne, Indiana, 200 x 300 feet. All-welded design. Note steel sash continuous.



Shipping Shop-welded Truss Sections for Assembly into Complete Trusses by Field Welding.

The Skilled Welder at Work in his Shop.

Welding the Steel for General Electric Building at Fort Wayne. View in Austin Steel Fabricating Shop Welding Department. Note Overhead Semi-Automatic Equipment.

General Electric New Million Dollar Filament Plant, Cleveland, Austin Welded ElecKtro-Design "Semi-Controlled Conditions Plant."

THE WINDOWLESS FACTORY

For the first time in history modern science will be drawn upon to provide ideal environment for factory workers, when Simonds Industries, Inc., saw manufacturers, opens their new windowless factory, a "Controlled Conditions Plant" at Fitchburg, Mass. The plant was designed and is now being constructed by The Austin Company, international firm of engineers and builders of Cleveland. All welded structural steel has been erected, and most of the exterior brickwork has been completed. The plant is of one story construction, 360 feet wide and 560 feet long.

Windowless buildings have been discussed for some years and in Germany a large movie studio has been constructed without windows. The Austin Company has pioneered in the building of large talking picture studios in California, but the Simonds factory will be the first instance in industry of the adoption of this advanced practice. The use of a windowless building requires two things, artificial light and ventilation. For this building systems are designed for illumination and ventilation far superior to that provided through windows and skylights.

In planning the building, every factor affecting the five senses of human beings has been studied and analyzed with the utmost scientific care to the end that conditions will be created that will be more ideally conducive to comfort for operatives, and consequently greater efficiency.

One of the important features will be noise absorption through acoustical walls, ceilings, and other means. The visibility of the machines will be lifted through the innovation of orange-colored paint for equipment. Experiments conducted by the company have indicated that an increase in efficiency by as much as 33 per cent may result from the new methods which will tend to reduce noise, fatigue and nervous strain.

The conditions of the plant will permit the operation of two shifts daily with the result that the company may produce a given amount of output with an investment equivalent to one-half the amount that would be required for the ordinary factory designed for one day-time shift.

This phase of the new building is attracting wide attention among industrial executives, offering as it does a revolutionary method of reducing overhead costs.

[1] See THE GLASS INDUSTRY, Vol. 11, No. 3 (Mar.) 1930, pp. 68-69.

ALL CONTINGENCIES PROVIDED FOR

Under ordinary working conditions in a factory illuminated by daylight, the light is changing constantly so that it is for periods of short duration only that each machine, desk or bench receives the kind and amount of illumination best suited to the eye and which enables the workers to produce with the least strain and effort. Natural light is constantly varying in intensity due to clouds and changing weather conditions. It will concentrate close to the windows, and other parts of the building may be in semi-darkness.

In this plant, lighting will be accomplished with 1,000-watt lamps equipped with diffusing shades giving a uniform light intensity on the working plane. This intensity promotes the ability to see and the speed of vision, thus reducing the hazard of accident.

Provision has also been made so that in case the power should fail at any time an emergency lighting system, operated by storage batteries, would automatically be thrown on.

The lighting system providing one sheet of light of equal intensity over the entire building is expected to make it easier to achieve uniform quality of product. A small percentage of light from the lamps will be reflected above to the ceiling, for the purpose of creating a more cheerful atmosphere in the building and assisting in the general diffusion of light.

Next to the problem of lighting, that of ventilation is the most important in the design of the building. Every precaution has been taken to insure the health and comfort of employes. Through automatic humidity control the moisture content of the air will be kept at the point most beneficial to health. Temperature also will be controlled and every 10 minutes over 500,000 cubic feet of air tempered to right condition and cleansed of dust and other outdoor impurities by washing and filtering will be brought into the building, making a complete change.

In hot weather, the air will be cooled through evaporation by atomized spray banks. In cold weather the air will be heated through coils in auxiliary fan houses through which the air will pass after washing. The air will be delivered to various sections of the building through ducts. The heating system will be under thermostatic control. All fumes, gases, exhausts and excess heat are removed from the building by underground ducts,

Special study has been given to the problem of eliminating drafts, and fresh air is so delivered that employes will feel only the freshness of a slowly moving body of air. By control of humidity in winter a great deal of usual trouble from colds and similar diseases will be avoided.

In order to lessen the nervous tension and distractions incident to modern factory din, extensive study has been made in search of a solution of the problems of noise reduction. The result is to be accomplished in a number of ways, through acoustical walls, ceiling and floor, through the isolation and padding of large machines and drop hammers and by actual silencing processes. Machinery causing noise and vibration will be isolated from the body of the floor and cushioned with cork pads.

Noises from material in process of manufacture will be reduced by masking, tempering and dampening. The process of masking allows different noises of similar frequencies to counteract each other, while the process of tempering involves placing shields in machines where noise originates to intercept the wave action. In dampening, the material is restrained from giving out sound after the fashion of a tuning fork.

The roof of the building is of particular interest. Like the walls, it is wholly solid, being of a metal acoustical type of high efficiency. The first layer of the roof's composition is a structurally strong perforated metal roof deck to permit passage of sound. Above this is an inch-and-a-quarter layer of rock fiber bound with asphalt. Over this are two one-half inch layers of insulating board secured in asphalt. On top of this is a built-up water proofing. In addition to sound absorption qualities the roof has insulating qualities as well, keeping out heat from the sun in summer and retaining heat within the building in winter.

The walls of the building will be acoustical block with a facing of brick for architectural effect. It is expected that the building will absorb at least 60 per cent of the usual sounds. Workmen near large machines will be able to converse in ordinary tones.

The plant also will embody the latest results of psychological research into the effects of color in depressing or energizing human beings. Colors for the interior have been selected with a view of attaining the best possible reaction from workmen, tending to keep them in a cheerful and active frame of mind while employed.

The machinery layout of the plant will provide for straight-line production and it will be planned to reduce industrial fatigue to a minimum. Unnecessary motions will be eliminated from all operations and physical effort of the workmen will be reduced as much as possible.

The building will be of single-story construction with no partitions and only 56 columns in the entire structure.

The Simonds Industries, Inc., famous saws are widely known and it is one of the most successful enterprises of New England. Although nearly 100 years old, it is famed for its progressive ideas. The president, A. T. Simonds, is nationally known as a student of practical business economics. It was founded in 1832 to manufacture scythes. Later it started the manufacture of saws, and it is now the largest producer of saws in the world. In addition to saws the company makes machine knives, abrasives, electric tools and files. The Company has a number of factories, a steel mill and more than a score of sales offices and service stations. The steel mill is located at Lockport, N. Y. Two of the factories are at Fitchburg, Mass., one in Chicago, one at Pittsburgh, one at Philadelphia, one at Seattle and one in Canada. All the work now being done in the Chicago plant and the two plants in Fitchburg will be concentrated in the new plant.

RELEVANT LITERATURE AVAILABLE

The "Controlled Conditions Plant," A Revolutionary Development in Industry, published by the Research Division of the Austin Company, engineers and builders, Cleveland. A 16-page pamphlet explaining how substantial cuts in producing costs, greatly reduced plant investment, improved quality of production are accomplished by means of "Controlled Conditions." Included are new achievements in straight-line production, reduction in plant investment of 20 to 40 per cent by operating two daytime shifts, complete flexibility of the plant to meet changing conditions, slashing the cost of machinery obsolescence, relocation of plants, controlled light, importance of controlled humidity, temperature and ventilation, and controlled sound in reducing production costs, industrial value of color, high cost of accidents, a manufacturing plant as a mammoth machine, etc.

"The Relation of Building and Equipment Design and Layout to Overhead Production," a paper presented by W. J. Austin, president of the Austin Company at the American Management Association Production Conference, Rochester, N. Y., June, 1921. A 16-page report by the American Management Association, 20 Vesey Street, New York, available to non-members at moderate cost, discusses the best types of buildings for continuous, intermittent and special production, elimination of overhead by proper design, effect of design and layout on plant efficiency, and control of weather conditions as related to the worker and the process, proper lighting, heating, good air, and proper humidity control. Also, when does a properly designed building become obsolete? How may the arrangement of equipment reduce cost? The new Simonds Industries, Inc., "Controlled Conditions" building and the savings it is expected to achieve. Discussion of above papers by members and speaker.

"Welding for Profit" was discussed by P. J. Horgan of the General Electric Company, Robert Kinkead, consulting engineer, of Cleveland, and Fred T. Llewellyn of the United States Steel Corporation. At the annual convention of the American Institute of Steel Construction, White Sulphur Springs, W. Va., on October 27, 1931.

Industrial Publication

Electric Furnaces.—Revised 24-page bulletin GEA-1146A, General Electric Company, Schenectady, N. Y. Includes illustrations of an electric glass annealing lehr rated 1,600 kw., inside width 13 feet 6 inches overall, length 730 feet, for annealing 12 tons of glass per hour. Also an illustration of the delivery end of one of 14 electric glass annealing lehrs installed in a bottle plant. One bottle manufacturer, who formerly experienced a breakage average of 2 per cent with fuel heat, has a record of four bottles broken in his electric lehr out of a total of 720,000. The total cost for electric annealing is a negligible item in the over-all cost. The additional cost for power over fuel may be offset by savings effected, because the necessity for washing is offset by savings effected, because the necessity for washing the finished product is eliminated.

Recent Patents

NEW INVENTIONS DESIGNED TO IMPROVE GLASS AND THE MEANS OF PRODUCING IT

Complete copies of U. S. Patent Specifications may be obtained from the Commissioner of Patents, Washington, D. C., Price 10c each

APPARATUS FOR MAKING PLATE GLASS. U. S. 1,825,853. Oct. 6, 1931. Robert L. Clause, Sewickley, Pa., assignor to Pittsburgh Plate Glass Company. Filed 9/20/29.

METHOD OF AND APPARATUS FOR TRANSFERRING GLASS PARISONS. U. S. 1,826,019. Oct. 6, 1931. Karl E. Peiler, West Hartford, Conn., assignor to Hartford-Empire Company, Hartford, Conn. Filed 8/11/24.

SHEET GLASS APPARATUS. U. S. 1,826,006. Oct. 6, 1931. Karl Kupferschmid, Toledo, O., assignor to Libbey-Owens-Ford Glass Company, Toledo, O. Filed 4/3/29.

GLASSWARE FORMING MACHINE. U. S. 1,827,698. Oct. 13, 1931. Joseph P. Benoit, Alton, Ill., assignor to Owens-Illinois Glass Company. Filed 6/27/30.

APPARATUS FOR MAKING SHEET GLASS. U. S. 1,827,459. Oct. 13, 1931. Roy C. Conn, Clarksburg, W. Va., assignor to Pittsburgh Plate Glass Company. Filed 5/27/30.

APPARATUS FOR ROLLING GLASS. U. S. 1,827,155. Oct. 13, 1931. Claude Locreille, Fanquez, Belgium. Filed 3/31/30 and in Belgium 4/6/29.

PROCESS OF AND APPARATUS FOR ROLLING GLASS. U. S. 1,827,138. Oct. 13, 1931. Arthur Brancart, Ronquieres, Belgium. Filed 2/14/30, and in Belgium 2/23/29.

GLASS FEEDING MACHINE. U. S. 1,823,062. Sept. 15, 1931. Claude W. Pleukharp and Harry Raynes, San Francisco, Calif., assignors to Hartford-Empire Company, Hartford, Conn. Filed 6/12/22. A plurality of delivering devices for delivering measured quantities of molten glass to different stations and comprising each a swinging chute, and means to control said swinging chutes to vary the time of movement of one with relation to the other.

MEANS FOR INTRODUCING BATCH INGREDIENTS INTO GLASS MELTING FURNACES. U. S. 1,822,705. Sept. 8, 1931. Nestor Mambourg, Lancaster, O., assignor to Libbey-Owens-Ford Glass Company. Filed 9/14/28. A plurality of inclined plate members carried by the buckstays and arranged between the same and projecting slightly into the furnace through said opening, said members being adapted to receive the batch and feed it into the furnace throughout substantially the entire width thereof, an adjustable gate associated with each opening and through which said members also project, a hopper associated with each member for initially receiving the batch and delivering it thereto, and a rotatable batch feed control member within each hopper.

MAKING SHEET GLASS. U. S. 1,823,357. Sept. 15, 1931. Robert L. Frink, Lancaster, O. Filed 7/27/27. Comprises substantially, continuously forming a glass sheet, causing the same to travel in an unsupported horizontally-extending path whereby the glass droops in such travel, and thereafter causing flexing of the glass in a direction opposite to the direction opposite to the direction in which it is flexed during such drooping.

APPARATUS FOR MAKING GLASS.. U. S. 1,827,471. Oct. 13, 1931. Harry F. Hitner, Oakmont, Pa., assignor to Pittsburgh Plate Glass Company. Filed 12/22/28.

Important Change in Vitaglass Corporation

Milton T. Clark, former vice-president of Truscon Steel Company and more recently president of the Campbell Industrial Window Company, has become president and a director of the Vitaglass Corporation. Percy H. Jennings, former president, has been elected chairman of the board of directors and treasurer, and will continue actively in the affairs of the corporation.

Formal announcement was made also of the recent inauguration of American production of Vitaglass at Clarksburg, W. Va.; new prices made possible by American production which are approximately one-fifth the prices originally charged for the imported product; and important changes in distribution policy which make it possible to obtain Vitaglass in all its several forms through all qualified glass distributors throughout the United States, and thus upon order, through any retail glass outlet.

Mr. Clark was for six years chief of the bureau of architecture and superintendent of public building construction for the city and county of San Francisco during the important period of reconstruction following the great fire.

Mr. Clark joined the Truscon Steel Company in 1920 as manager of its window division and became vice-president in February, 1928. In 1930 he became president of the Campbell Industrial Window Company, a division of the American Radiator-Standard Sanitary Corporation, from which he resigned just prior to accepting the presidency of the Vitaglass Corporation.

Approximately seven years ago the formula for Vitaglass was discovered in England. It was the first commercially practical ultra-violet ray transmitting glass, passing those invisible rays of light which are scientifically known to have distinct health properties. Two years later, the Vitaglass Corporation began its distribution in the United States. The success of this "superglass" was phenomenal from the very start and its acceptance mounted in spite of a price level of around $2.50 a square foot. Many people in the building industry recall the discovery that all ultra-violet ray transmitting glasses solarized upon exposure which had the effect of reducing their ultra-violet ray transmitting properties, but relatively few were aware that Vitaglass stabilized upon exposure and retained permanently its properties to transmit health rays in adequate quantity. Physicists and many medical research scientists tested these materials most thoroughly, and the result of their findings not only proved the value of Vitaglass as a health medium but further proved that its beneficial effects were permanent and were obtainable through windows facing all exposures, whether or not they received the direct rays of the sun.

Mr. Clark said: "In joining hands with this pioneer producer of ultra-violet ray health glass, I was largely influenced by the conviction that in the future all buildings housing human occupants and all farm buildings housing productive live stock and poultry will eventually be glazed with glass of this type. Its beneficial values are so positively established that no intelligent building owner will in the future tolerate shutting out the health rays from the sun in the last few feet of their 93 million miles of travel. A second factor in my decision was the fact that with the inauguration of American manufacture, employing the most modern scientific process for producing flat vertical drawn window glass (Fourcault process), we could so substantially reduce the cost of the glass as to make it economical for use in every building. This American-made Vitaglass is superior in flatness, clarity, brilliance and finish to the imported product at one-fifth of its former price levels."

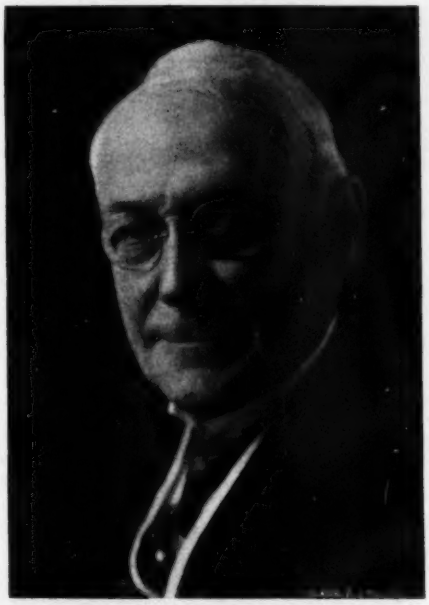
The new directors of the Vitaglass Corporation elected or confirmed at a recent stockholders' meeting include, in addition to Mr. Jennings and Mr. Clark: Winthrop M. Crane, president of Crane & Company; Walter L. Chance, chairman, Chance Brothers & Co., Ltd., Smithwick, Birmingham, England; Arnold L. Davis, member of the law firm of Davis, Wagner & Heater; Lawson Purdy, director of Charity Organization Society; Raymond Newman, vice-president, Corporation Trust Company, New York; Herbert Maynard, Jr., president Maynard & Child, Inc., Boston, Mass.; Floyd W. Parsons, editorial director, Robbins Publishing Company, New York; Dr. Earl H. Mayne, president and director of Bay Ridge Sanitarium, Inc.; Donald E. Sharp, Glass Consulting Engineer, Hamburg, N. Y.

The Glass World and What It Is Doing

News of the Industry

Industry Loses Prominent Leader

No man who had ever come in contact with William Lewis Clause, for many years Chairman of the Pittsburgh Plate Glass Company's board of directors, could avoid deep feelings of regret when learning of his death on October 7, and thousands of men connected with the glass industry and with the numerous



WILLIAM L. CLAUSE

other activities in which he was financially or socially interested have felt his loss very keenly.

Mr. Clause was born on a farm in Medina County, O., and obtained his education in the grammar and high schools of Akron, O. While still a young man he became connected with a plate glass factory at Kokomo, Indiana. A few years after that he joined the sales force of the Pittsburgh Plate Glass Company and gradually advanced to be president in 1905. From that date to 1916 he remained in that office and from 1916 to his death he was Chairman of the Board.

Through his ability Mr. Clause with his associates including Captain Charles W. Brown, the company's capitalization was increased from $10,000,000 in 1895 and assets of $15,000,000 to its present capitalization of $65,000,000 with assets of practically $100,000,000.

It was not only Mr. Clause's business ability as a leading executive and his strength in financial affairs that brought him prominence and made him one of the most important business men of the Pittsburgh district, but also his winning personality which made hosts of friends for him.

In addition to business affairs he devoted considerable time to educational affairs, having been a Trustee of the University of Pittsburgh and for a considerable period President of the Board of Trustees of Grove City College. He was also a director in several hospitals. He loved the outdoors and had a summer home in Canada.

Mr. Clause in 1881 married Miss Elizabeth Ann Fish. He left three daughters and a son Robert Lewis Clause, present Vice-President and Chairman of the Manufacturing Department of the Pittsburgh Plate Glass Company.

There are also a number of grandchildren surviving him.

Liberty Glass Operating Close to Capacity

The Liberty Glass Company of Sapulpa, stated to be the only exclusive manufacturer of milk bottles west of the Mississippi River, reports a decided increase in production since last May and expects to soon be operating the plant at its full capacity. The concern is one of the six companies in the United States manufacturing 95 per cent of the milk bottles of the country. The plant is capable of making 16,000,000 bottles per year, and last year its output was 15,840,000 bottles. Not being subject to seasonal demands, the plant operates full time the year 'round, and has a payroll of 100 employees working in three eight-hour shifts.

Export trade furnishes the company with one of its important markets, bottles being shipped to Cuba, Canada and Mexico in carload lots. The United States marketing area of the firm extends from Tennessee and Lake Michigan to Nevada and Idaho. George Collins is president of the company. He attributes the large increase in the use of milk bottles to the lower price of milk, which makes it a cheaper and more widely used food product.

February Art Exhibition of American Ceramic Society

The exhibition committee of the Art Division of the American Ceramic Society has issued a letter to division members stating that the committee is suggesting five main groups to be considered by those planning their entree at the exhibition to be held in connection with the annual meeting of the Society at Washington next February, as listed below:

(1) Experimental processes in any field of ceramics which might be useful to a manufacturer or craftsman carrying on mass production.

(2) Pieces so designed that they would be practical for mass production.

(3) Well-rendered designs which may be accompanied by an executed portion of the design or well-rendered designs using standard ceramic products.

(4) Ceramic models of objects too large to exhibit.

(5) Individual pieces.

Hitherto, the exhibition has been made up mostly of the last group. This year the craftsmen are urged to contribute also toward the other four groups.

Each person, by paying an entry fee may exhibit eight pieces in group five. Those also interested in helping solve the problems of design for mass production will be allowed to exhibit free, eight pieces classified under groups one to four, inclusive.

Mirror Frame and Picture Frame Industry Sales

The Bureau of the Census recently released data on the distribution of sales 1929 of the mirror frame and picture frame industry. There are 178 establishments engaged wholly or principally in the manufacture of mirror frames and picture frames; finished mirror and picture frame moldings; and frames and moldings, not separately reported. The summary for 1929 gives the total factories sale value as $19,167,000, the total number of plants 178. 1.8% of sales was to manufacturers' own wholesale branches; 2.2% sales to manufacturers' own retail branches; sales to wholesale dealers 30.7%; retail dealers 57.3%; sales to large users 4.9%; sales to household users 3.1%. Copies of the report and a distribution chart may be obtained from the Census Bureau.

Construction Records for Third Quarter

F. W. Dodge Corporation reports on construction contracts in the third quarter of 1930 show a general loss of 26 per cent for the 37 states east of the Rockies. Numerous exceptions occurred, however, such as a 29 per cent advance in engineering in northern New York, 6 per cent in the Middle Atlantic District, 34 per cent on residential building in the Chicago territory, 3 per cent in non-residential, 248 per cent in engineering in the New Orleans territory and 14 per cent in engineering in Texas.

Imports and Foreign Tariffs Hurt Belgium's Glass Trade

The following extract from the News Edition of *Industrial & Engineering Chemistry* for October 20, 1931, will interest our readers. It is taken from the regular news letter from Belgium by C. Mathy, Brussels.

GLASS INDUSTRY FEELS DEPRESSION

It has taken the present economic crisis to renew interest in and to consummate the plan started in 1903 by several master stained-glass makers, namely, the Union of Belgian Mechanical Glass Works using the Fourcault process, of which we spoke in our Belgian Letter of December 20, 1930. This agreement enables our stained-glass factories to pass through the present depression without too much anxiety. As we have already stated, our stained-glass factories export about 90 per cent of their production. The increased duty to be paid in foreign countries creates new difficulties. Although decreasing production, the works are able to keep their ovens going and to reduce the idleness of the workmen to a minimum.

The table glassware industry is more affected. The ever mounting number of new factories has increased production to such proportions that all markets have become flooded. The application of machinery to the manufacture of table glassware makes possible the manufacture of ordinary products at low prices. Our country, a great exporter of table glassware, has not even succeeded in stopping the inflow of foreign products in this line.

The manufacture of crystal is not so much affected, but, carried on as it is for export, it experiences the same difficulties as do the stained-glass and plate-glass industries. We note that an association or federation is now being discussed, which would bring together the majority of our glassworks.

Finally, an organization of Belgian bottle-makers has recently been effected, whose aim is to regulate the production and sale of articles made in the industry. Four companies form this coalition, which seems destined to play an important role in the Belgian bottle-making industry.

New "Free Vane" Recorder Controller

A new departure in air operated recording controllers has been announced by The Bristol Company, Waterbury, Conn. A "free vane" is employed to initiate the control. It is attached to and actuated by a measuring element of a temperature or recording pressure system. The "free vane" moves between two air jets with stream lines coinciding placed opposite each other. In passing into these air streams it varies the amount of air which escapes from the jets, thus effecting control. The position of the vane is such that the position and movement of the measuring elements are not affected and the recording device therefore, it is stated, reproduces the temperature or pressure with complete accuracy.

As seen in Fig. 1, air at 15 lbs. pressure is admitted through connection (7) and carried through filter (8), one branch leading to an indicating gauge (9). The other branch turns to the left and supplies air to the control system. This supply branch in turn divides into two branches, one passes through an orifice (10) supplying the elastic element (11) and then through a connecting line to the opposing jets (5) and (6). The other branch supplies air to the pilot valve (12) and through the pilot valve to the indicating gauge (14) and outward to the top of the diaphragm motor valve (13).

The air which enters through orifice (10) is dissipated through jets (5) and (6). The amount which may be dissipated through these jets depends upon the position of the free vane (4). This vane, being directly attached to an elastic element (1) of the hollow helical type, is moved by changes in the temperature at the sensitive bulb shown in the bath at the lower right hand corner. The changing amount of dissipated air at jets (5) and (6) produces a pressure change on the elastic element (11) and a consequent deformation which operates pilot valve (12) admitting more or less air to the top for operating the diaphragm motor valve (13). The elastic element (1) also carries the recording penarm which is attached to the shaft (3).

The Free Vane Recorder Controller is enclosed in a two part cast-aluminum case of moisture-proof construction. It is furnished with inverted penarm and fountain pen as standard equipment. The chart is rotated by a powerful spring clock or Bristol's Telechron Operated clock. The case is available for wall or flush mounting. It is furnished as a single or two-pen instrument in combination of pressure or temperature and has a pressure range up to 1,500 pounds per square inch and temperature range up to 1000° F., using 12" charts. Temperature measuring systems may

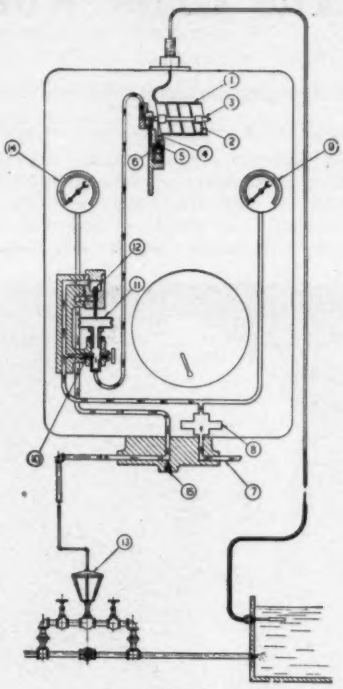
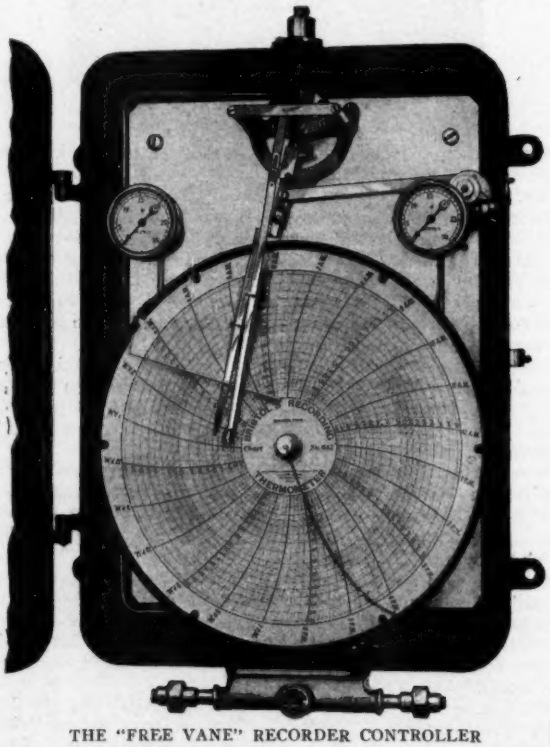


FIG. 1

be either vapor or gas filled depending on the operating temperatures encountered.

Patents covering this method of control are applied for and



THE "FREE VANE" RECORDER CONTROLLER

pending. The company has a new catalog illustrating and describing this instrument ready for distribution.

Dr. Sells' New English-French Technical Dictionary

An important forthcoming publication that will doubtless arouse interest throughout all the mechanical industries, automobile and motoring fields, etc., is the Comprehensive Technical Dictionary of the Automobile and Allied Industries in English and French, compiled by Lewis L. Sell, Ph.D., with the collaboration of leading manufacturers. This work, in view of the amount of time and labor involved in its preparation and production and the remarkable results attained is an impressive work.

It was compiled with the aid of the leading manufacturers of France, England, and the United States, and more than 1,000 specialists in their various fields were consulted in an effort to make the terminology fit the needs of actual practice. More than 4,000 letters were exchanged and a combined period of more than 30,000 hours of research, of which 12,000 hours were spent by the author himself, was required to collate the hitherto unattained number of 150,000 terms in the two languages, at a total business outlay of $125,000, all borne by the author himself.

It covers the full terminology of motordom and all its allied fields, and has been in work for several years. It will fill an enormous gap by uniting in a single handy volume the thus far scattered, and often confusing terminology of more than 100 fields of industry, centering around the motor car, and including the glass industry. It not only gives the mechanical field an indispensable tool of undoubted understanding, but through its new method of grouping all synonyms under a central heading, it enables the user of the work to consult it in either language for the variations of expression, which dictionaries thus far published lacked even elementary coordination.

The book may be obtained from local dealers, or direct from the International Dictionary Company, 15 Park Row, New York, the price having been set at the low figure of $6.00 per volume.

The Carborundum Company, Niagara Falls, N. Y., abrasive manufacturers and specialists in lehr refractories at their Perth Amboy, N. J., plant, resumed on October 31 its weekly radio program through the facilities of the Columbia Broadcasting System. The entire supervision of the program, its preparation, continuity and orchestration, is under the direction of Francis Bowman, advertising manager of the company at Niagara Falls, who also acts as program announcer.

Dr. Burgess Stricken

Dr. George A. Burgess, director of the Bureau of Standards at Washington, D. C., suffered a collapse on October 28 while attending a meeting at the Bureau. He was taken to the Emergency Hospital, where it was reported the cause of trouble was a slight attack of cerebral hemorrhage.

Coming Meetings

The National Glass Distributors Association will hold its annual meeting in Pittsburgh, December 1-3, 1931.

Eastern Division of the National Glass Distributors Association will hold a meeting November 5 at the McAlpin Hotel, New York.

What the World Wants

Specific Inquiries for American Goods Received in the Department of Commerce, Washington, D. C. For further information write the department.

Canada—54091. Glass jars, complete with lids, for facial creams, etc.

Chile—54302. Glass and chinaware.

Readers Wants and Offers

Address answers to all "keyed" ads c/o The GLASS INDUSTRY, 24 West 40th St., New York

SITUATION WANTED

By Glass Technologist and Engineer, as factory manager, now employed. Many years' experience on both plain and colored glass, tanks and pot furnaces. Would like to get in touch with some progressive company who want to do things. Address Box O-1, as noted above.

WILL PAY REASONABLE PRICE
for a copy of July, 1927, issue of
THE GLASS INDUSTRY
in good condition.
Address NX, c/o THE GLASS INDUSTRY.

Statement of the Ownership, Management, Circulation, etc., required by the Act of Congress of August 24, 1912, of THE GLASS INDUSTRY, published monthly, at New York ,N. Y., for October, 1931. State of New York. County of New York—ss. Before me, a Notary Public, in and for the State and County aforesaid, personally appeared G. W. Cooper, who, having been duly sworn according to law, deposes and says that he is the business manager of THE GLASS INDUSTRY, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Glass Industry Publishing Co., Inc., 24 W. 40th St., New York; editors, D. E. Sharp and F. W. Preston; managing editor, G. W. Cooper, 24 W. 40th St., New York; business manager, G. W. Cooper, 24 W. 40th St., New York.

2. That the owners are (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock): Glass Industry Publishing Co., Inc., 24 W. 40th St., New York; G. W. Cooper, 24 W. 40th St., New York; R. D. Proctor, 24 W. 40th St., New York.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are (If there are none, so state): None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting is given; also that the said two paragraphs contain statements, embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him. G. W. COOPER, Managing Editor. Sworn to and subscribed before me this 23rd day of September, 1931. [Seal] ISABEL MARY, Notary Public. (My commission expires March 30, 1932.)

SPECIALISTS ON
LUMINOUS FLAME
INSTALLATIONS

TOLEDO ENGINEERING CO., Incorporated
983 Front Street, Toledo, Ohio

Current Prices of Glass-Making Materials

October 23, 1931

Quotations furnished by various producers, manufacturers and dealers

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	..	.35
Hydrochloric (HCl) 20° tanks, per 100 lb		..	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	..	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 38° carboy ext. Per 100 lb.		5.50	..
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	..
Tartaric	lb.	..	.26½
Alcohol, denatured	gal.	..	..
Aluminum hydrate ($Al(OH)_3$)	lb.	.04½-.05	.05½-.06
Aluminum oxide (Al_2O_3)	lb	..	.07
Ammonium bifluoride (NH_4) FHF	lb.	..	.15½
Ammonia water (NH_4OH) 26° drums	lb.	..	..
Antimony, metallic (Sb)	lb.	.02½	.02¾
Antimony oxide (Sb_2O_3)	lb.	..	.09¾
Antimony sulphide (Sb_2S_3)	lb.	..	.08½
Arsenic trioxide (As_2O_3) (dense white), 99%	lb.	.04	.14 .04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	47.00	..
90% through 100 mesh	ton	44.00	..
Barium hydrate ($Ba(OH)_2$)	lb.	..	.05¼
Barium mixture, glassmaker's, f.o.b. St. Louis	ton	25.00	..
Barium nitrate ($Ba(NO_3)_2$)	lb.	..	.07¼
Barium selenite ($BaSeO_3$)	lb.	..	..
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk, f.o.b. shipping point,	ton	15.00-16.00	18.00
Bone ash	carlots, lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	..	.0355-.0425
Crystal	lb.	.028-.033	..
Granulated	lb.	.025-.03	..
Powdered	lb.	.02875-.03375	..
Boric acid (H_3BO_3)	lb.	.0625-.07125	.0625-.08125
Refined	lb.	.0625-.07125	.07125-.08125
Cadmium sulphide (CdS)—			
Red	lb	..	.65-.90
Orange	lb.	..	.60-1.10
Yellow	lb.	..	1.30-1.50
Chromium oxide (Cr_2O_3)	lb.	.23	.24
Cobalt oxide (Co_2O_3)			
In bbls.	lb	..	1.35-1.45
In 10 lb. tins	lb	..	1.45
Copper oxide			
Red (Cu_2O)	lb.	..	.25
Black (CuO)	lb	..	.17-.19
Black prepared	lb.	..	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland			
Kryolith)	lb.	.09	.09¼
Synthetic (Artificial)	lb.	..	.09½
Epsom salts ($MgSO_4$) (imported) Per 100 lb		..	1.15-1.20
*Feldspar—			
100 mesh	ton	11.50-17.50	12.00-18.00
80 mesh	ton	11.00-11.50	13.00
40 mesh	ton	10.75-11.00	12.00
20 mesh	ton	9.50- 9.75	10.00
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f.o.b. mines	ton	30.00	..
In bags or barrels	ton	34.00	39.00
Imported	ton	30.00-31.00	33.00-37.00
Formaldehyde	lb.	..	.07
Graphite (C)	lb	..	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb	..	.0425
Black (FeO)	lb	.04½	..
Kaolin (f.o.b. mine)	ton	8.00-9.00	..
English, lump, f.o.b. New York	ton	14.50-25.00	24.50-30.00

*Spot Shipments.

		Carlots	Less Carlots
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb	..	30
Lead oxide (Pb_3O_4) (red lead)	lb	.0625	.0725
Litharge (PbO)	lb.	.0525	.0625
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	7.00	7.00
Burnt (CaO) ground, in bulk	ton	6.00	..
Burnt, ground, in paper sacks	ton	8.00	8.00
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.15	..
Limestone ($CaCO_3$)		1.50-2.50	1.75-2.50
Magnesia (MgO)—			
Calcined, heavy (in bbls.)	lb	.06	.07
light (in bbls.)	lb	..	.23
extra light (in bbls.)	lb.	..	.37
Magnesium carbonate ($MgCO_3$)	lb.	.06	.10
Manganese 85% (MnO_2)	lb.	.03	.03
Nickel oxide (Ni_2O_3), black— for nickel content	lb	..	.35
Nickel monoxide (NiO), green— for nickel content	lb	..	.35
Plaster of Paris, bags	ton	21.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb	.09	.09¼
Ground	lb	.11	.12
Potassium carbonate—94-96%	lb.	.0555	.0555
Calcined (K_2CO_3) 96-98%	lb.	.06½	.07¼
Hydrated 80-85%	lb.	.05¾	.06¼
Potassium chromate (K_2CrO_4)	lb.	..	.25
Potassium hydrate (KOH) (caustic potash)	lb	.07½	.08
Potassium nitrate (KNO_3) (gran.)	lb.	..	.06½-.06¾
Potassium permanganate ($KMnO_4$)	lb.	.16	.17
Powdered blue	lb.	..	.17½-.18
Rochelle salts, bbls.	lb.	..	.16½-.19
Rouge	lb.	..	..
Rutile (TiO_2) powdered, 95%	lb	.15-.20	20-.25
Salt cake, glassmakers (Na_2SO_4)	ton	22.00	..
Selenium (Se)	lb.	..	1.80
Silver nitrate ($AgNO_3$)	(100 oz.) per oz.	..	.23
Soda ash (Na_2CO_3) dense, 58%—			
Bulk, on contract	Flat per 100 lb.	1.07½	..
In barrels	Per 100 lb.	1.38	1.90-2.00
In bags	Per 100 lb.	1.17½	1.72½
Spot orders.. .025 per 100 lbs. higher		..	..
Sodium bichromate ($Na_2Cr_2O_7$)	lb	.07	.07½
Sodium hydrate (NaOH) (caustic soda) Solid	Per 100 lb.	2.50	..
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	lb.	..	..
95 per cent.	Per 100 lb.	1.67-177	1.72-1.82
Sodium selenite (Na_2SeO_3)	lb	..	2.00
Sodium fluosilicate (Na_2SiF_6)	lb.	.04	.04½
Sodium uranate (Na_2UO_4) Yellow or Orange	lb.	..	1.50-1.55
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb	3.45	3.80-4.00
Flowers, in bags	Per 100 lb	3.10	3.45-3.65
Flour, heavy in bbls.	Per 100 lb	2.85	3.20-3.40
Tin chloride ($SnCl_2$) (crystals)	lb	.37½	.39
Tin oxide (SnO_2) in bbls.	lb.	.28	.29½
Uranium oxide (UO_2) (black, 96% U_3O_4)			
100 lb. lots. Black	lb.	..	2.75
Yellow	lb.	..	1.50
Zinc oxide (ZnO)	lb.	.08½	.12
American process, Bags	lb.	.06½	.07
Zircon			
Granular (Milled .005-.02c higher)		.07	.07½-.08
Crude. Gran. (Milled .005-.02c higher)		03½	.04-.05

Monthly Summary of United States Foreign Commerce in Glass

EXPORTS

Corrected to September 25, 1931.

	August 1930 Quantity	August 1930 Value	August 1931 Quantity	August 1931 Value	Eight Months Ending August 1930 Quantity	Eight Months Ending August 1930 Value	Eight Months Ending August 1931 Quantity	Eight Months Ending August 1931 Value
Glass and glass products (Total)	.....	$792,077	.....	$469,878	.....	$6,294,142	.....	$4,973,565
Plate and window glass—								
Window glass, common, box 50 sq. ft.	1,293	6,941	1,267	4,736	11,972	64,082	5,979	29,690
Plate glass, unsilvered, sq. ft.	233,961	71,734	204,200	63,839	2,379,855	725,515	2,722,175	830,699
Other window and plate glass lbs.	632,404	38,112	186,922	15,854	3,775,317	322,743	2,016,781	209,840
Glass containers (bottles, vials and jars)	.....	360,865	.....	181,324	.....	2,121,168	.....	1,489,543
Table glassware, plain	.....	75,471	.....	60,387	.....	798,058	.....	611,681
Table and other glassware, cut or engraved	.....	7,542	.....	4,817	.....	61,757	.....	58,041
Lamp chimneys and lantern globes lbs.	.....	19,323	.....	4,392	.....	164,641	.....	66,613
Globes and shades for lighting fixtures lbs.	.....	36,876	.....	23,631	.....	406,767	.....	283,771
Chemical glassware lbs.	23,447	21,840	11,168	8,993	163,772	153,377	101,576	99,919
Electrical glassware, except for lighting lbs.	117,621	9,553	80,915	5,278	2,917,929	192,259	1,091,838	71,138
Other glassware	.....	143,820	.....	961,627	.....	1,283,775	.....	1,222,630

IMPORTS

Corrected to September 25, 1931.

Glass and glass products	.....	$648,574	.....	$537,842	.....	$5,880,300	.....	$4,041,089
Cylinder, crown, and sheet—								
Plain dut. lb.	1,006,456	36,591	923,820	38,207	12,288,881	483,290	6,037,679	234,562
Bent, beveled, colored, etc. dut. lb.	230,692	25,284	128,951	19,997	.....	252,510	1,282,106	174,322
Plate glass dut. sq. ft.	280,993	59,713	283,335	47,364	3,713,520	813,541	3,415,309	868,053
Glass mirrors	126	270	97	359	291	495	1,050	2,758
Rolled, cylinder, crown, and sheet glass, ground, obscured, bent, beveled, colored, etc.	.....	4,780	.....	6,591	.....	9,394	.....	52,732
Laminated glass and manufactures, and plated glass	.....	2,146	.....	601	.....	6,930	.....	15,802
Bottles, vials, jars, and other containers	.....	53,651	.....	45,207	.....	822,035	.....	335,977
Scientific articles and utensils dut.	.....	38,181	.....	46,675	.....	377,034	.....	284,868
Tubes and rods dut.	.....	5,460	.....	17,889	.....	15,859	.....	91,525
Illuminating articles dut.	.....	41,616	.....	29,328	.....	409,653	.....	246,558
Blown glass articles—								
Bulbs for electric lamps, without filament dut.	.....	.....	945,642	8,388	.....	.....	9,091,010	85,693
Other blown glass articles dut.	.....	.....	.....	187,228	.....	.....	.....	984,303
Pressed glass articles	.....	33,773	.....	11,308	.....	129,060	.....	80,143
Other glassware	.....	84,670	.....	78,700	.....	736,964	.....	583,793